IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appln. No: 10/812,113
Appellant: Ming LI
Filed: March 29, 2004
Title: METHOD AND APPARATUS OF DRILLING HIGH DENSITY SUBMICRON CAVITIES USING PARALLEL LASER BEAMS
T.C./A.U.: 1725
Examiner: Elve, Maria Alexandra
Confirmation No.: 1523
Notice of Appeal Filed: July 6, 2007
Docket No.: MATB-401US

APPEAL BRIEF

Mail Stop Appeal Brief-Patents
Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

S I R :

In response to the Final Official Action dated April 6, 2007, and Notification of Non-Compliant Appeal Brief of November 27, 2007. Appellant is reinstating the appeal and submitting this Appeal Brief for the above-identified application.

I. REAL PARTY IN INTEREST

The Real Party in Interest in this matter is Matsushita Electric Industrial Co., Ltd.

II. RELATED APPEALS AND INTERFERENCES

There are no other appeals or interferences known to Appellant, Appellant's legal representative, or Assignee which may be related to, be directly affected by, or have a bearing on the Board's decision in the pending appeal.

III. STATUS OF CLAIMS

Claims 1, 5-14, 16-20, 22, 23, 25-29, and 32-34 are pending in this application. Claims 1, 5-14, 16-20, 22, 23, 25-29, and 32-34 stand rejected. Claims 1, 5-14, 16-20, 22, 23, 25-29, and 32-34 are appealed. Of those claims currently under appeal, claims 1, 5, 8, 11, 17, 20, 23, 26, and 32 are independent.

IV. STATUS OF AMENDMENTS

The present application is under final rejection. Appellant elected not to submit a Response After Final under 37 C.F.R. §1.116. Instead, Appellant filed a Notice of Appeal herewith. The present application has been rejected four times. Prior to the final rejection, Appellant filed two Amendments during prosecution. Both Amendments were entered.

V. SUMMARY OF CLAIMED SUBJECT MATTER

Claims 1, 5-14, 16-20, 22, 23, 25-29, and 32-34 are appealed. The claimed invention is directed to novel laser micromachining methods and systems for drilling holes in a work piece. In the claimed invention, multiple holes are drilled in a work piece parallel by separating a pulsed laser beam into a number of sub-beams. These sub-beams are formed using either a mask or a diffractive optical element (DOE) in the claimed invention. The sub-beams are focused onto the work piece surface using demagnifying optics. The diameter and pitch of the sub-beams is reduced by the demagnifying optics. The minimum pitch to which the sub-beams can be reduced by the demagnifying optics is determined by the wavelength (λ) of the pulsed laser beam based on their diffraction limited spot size (which is of the order of magnitude of λ); however, it is possible to drill holes that are smaller than the diffraction limited spot size of the sub-beams due to their

cross-sectional intensity profile, with careful control of the fluence of the pulsed laser beam.

The claimed invention takes advantage of this ability by drilling one set of holes with a pitch greater than λ, then moving the pattern of sub-beams and drilling another set of holes in between the first set of holes to achieve a final pattern of holes with a pitch less than λ.

The pattern of sub-beams is moved using a translation stage. Because the demagnifying optics reduce the dimensions of the pattern of the sub-beams, distance that the beam spots move on the work piece surface is equal to the distance that the sub-beams are moved times the demagnification factor of the demagnifying optics. So, if the demagnification factor of the demagnifying optics is 1/10, moving the pattern of beam spots (i.e. the location for the second set of holes) 1 micron on the surface of the work piece involves using the translation stage to move the sub-beams 10 microns. Thus, by translating the sub-beams and then reducing the sub-beam pattern, the claimed invention achieved improved precision for positioning the second set of holes.

In general terms, Appellant's claimed invention recites

In accordance with 37 C.F.R. § 41.37(c)(1)(v), concise explanations of the subject matter defined in independent claims 1, 5, 8, 11, 17, 20, 23, 26, and 32 are set for the below. Citations to the application's support for claimed subject matter are made by reference to page (pg.) and line numbers (lines) of Appellant's specification (*AS*) as originally filed (e.g., *AS* pg. 4, lines 12-15) as well as corresponding figures (Figs.).

Claim 1

Independent claim 1 broadly recites a laser micromachining system for drilling

holes in a work piece. *AS* pg. 4, lines 4-25; Fig. 1. The laser micromachining system includes a laser beam generator for directing a laser beam having a wavelength λ, along an optical path. *AS* pg. 7, line 12, through pg. 8, line 17; Fig. 1. The laser beam is received by an image interpolating mask, which is disposed in the optical path. The image interpolating mask has an array of apertures that form a corresponding array of sub-beams of a first pitch size, which is greater than λ, from the laser beam. *AS* pg. 9, lines 14-21; Fig. 2. The array of sub-beams is a sub-pattern of a reduced-size pattern formed on the work piece. *AS* pg. 14, line 13, through pg. 15, line 4; Fig. 6. A demagnifier is disposed in the optical path to form the reduced-size pattern of the array of sub-beams on the work piece. *AS* pg. 12, lines 1-5; Fig. 1. This reduced-size pattern has a second (reduced) pitch size, which is less than λ. A translation stage is coupled to the image interpolating mask to move the image interpolating mask and the array of sub-beams in a direction perpendicular to the optical path. *AS* pg. 10, lines 20-27; Fig. 1. This allows the array of sub-beams to be moved in a sequence by the translation stage to form the reduced-size pattern on the work piece, when the laser beam is generated. *AS* pg. 14, line 13, through pg. 15, line 4; Fig. 6.

Claims 5, 8, and 20

Independent claims 5, 8, and 20 broadly recite a laser micromachining system similar to the system of claim 1.

Claim 5 differs from claim 1 in that it recites that the array of apertures of the image interpolating mask has an aperture density of 1/N times an image density of the reduced-size pattern on the work piece times a demagnification factor of the demagnifier, where N is a positive integer. *AS* pg. 14, line 13, through pg. 15, line 4; Fig. 6. Thus, the sub-pattern of the reduced-size pattern formed on the work piece is translated N-times by

the translation stage to form the array of holes of the second pitch size (i.e. the reduced-size pattern). *AS* pg. 14, line 13, through pg. 15, line 4; Fig. 6.

Claim 8 differs from claim 1 in that it recites that each of the sub-beams formed by the image interpolating mask has a Gaussian intensity distribution and that at least one hole in the array of holes has a diameter of approximately less than or equal to the full width at half maximum (FWHM) of the Gaussian intensity distribution of the sub-beam. *AS* pg. 12, line 14, through pg. 13, line 7; Fig. 3.

Claim 20 differs from claim 1 in that it recites that the second pitch size is approximately equal to a Rayleigh distance of $0.61*\lambda/N.A.$, where N.A. is a numerical aperture of a lens in the optical path. *AS* pg. 13, line 11, through pg. 14, line 12; Figs. 4 and 5.

Claim 11

Independent claim 11 broadly recites a laser micromachining system for drilling holes in a work piece. *AS* pg. 4, line 26, through pg. 5, line 11; Fig. 8. The laser micromachining system includes a laser beam generator for directing a laser beam having a wavelength λ, along an optical path. *AS* pg. 7, line 12, through pg. 8, line 17; Fig. 1. The laser beam is received by a diffractive optical element (DOE) and a telecentric f-θ lens, which is disposed in the optical path, to form a corresponding array of sub-beams of a first pitch size, which is greater than λ. *AS* pg. 18, lines 8-23; Figs. 8 and 9. The array of sub-beams is a sub-pattern of a reduced-size pattern formed on the work piece. *AS* pg. 14, line 13, through pg. 15, line 4; Fig. 6. A demagnifier is disposed in the optical path to form the reduced-size pattern of the array of sub-beams on the work piece. *AS* pg. 12, lines 1-5; Fig. 1. This reduced-size pattern has a second (reduced) pitch size, which is

less than λ. The array of sub-beams formed by the DOE has a density of 1/N times the image density of the reduced-size pattern on the work piece times a demagnification factor of the demagnifier, where N is a positive integer. *AS* pg. 14, line 13, through pg. 15, line 4, and pg. 19, lines 15-26; Fig. 6. A translation stage is used to move the array of sub-beams in a direction perpendicular to the optical path. *AS* pg. 10, lines 20-27; Fig. 1. This allows the array of sub-beams to be moved N-times by the translation stage to form the array of holes of the second pitch size (i.e. the reduced-size pattern) on the work piece, when the laser beam is generated. *AS* pg. 14, line 13, through pg. 15, line 4, and pg. 19, lines 15-26; Fig. 6.

Claim 17

Independent claim 17 broadly recites a laser micromachining system for drilling holes in a work piece. *AS* pg. 4, line 26, through pg. 5, line 11; Fig. 8. The laser micromachining system includes a laser beam generator for directing a laser beam having a wavelength λ, along an optical path. *AS* pg. 7, line 12, through pg. 8, line 17; Fig. 1. The laser beam is received by a diffractive optical element (DOE) and a telecentric f-θ lens, which is disposed in the optical path, to form a corresponding array of sub-beams of a first pitch size, which is greater than λ. *AS* pg. 18, lines 8-23; Figs. 8 and 9. The array of sub-beams is a sub-pattern of a reduced-size pattern formed on the work piece. *AS* pg. 14, line 13, through pg. 15, line 4; Fig. 6. Each of the sub-beams has a Gaussian intensity distribution. *AS* pg. 18, lines 8-23. A demagnifier is disposed in the optical path to form the reduced-size pattern of the array of sub-beams on the work piece. *AS* pg. 12, lines 1-5; Fig. 1. A translation stage is used to move the array of sub-beams in a direction perpendicular to the optical path, thus forming the array of holes of the second pitch size (i.e. the reduced-size pattern) on the work piece, when the laser beam is generated. *AS*

pg. 10, lines 20-27, pg. 14, line 13, through pg. 15, line 4, and pg. 19, lines 15-26; Figs. 1 and 6. At least one of the holes of the array of holes has a diameter of approximately less than or equal to the full width at half maximum (FWHM) of the Gaussian intensity distribution. *AS* pg. 12, line 14, through pg. 13, line 7; Fig. 3.

Claim 23

Independent claim 23 broadly recites a laser micromachining system for drilling holes in a work piece. *AS* pg. 4, line 26, through pg. 5, line 11; Fig. 8. The laser micromachining system includes a laser beam generator for directing a laser beam having a wavelength λ, along an optical path. *AS* pg. 7, line 12, through pg. 8, line 17; Fig. 1. The laser beam is received by a diffractive optical element (DOE) and a telecentric f-θ lens, which is disposed in the optical path, to form a corresponding array of sub-beams of a first pitch size, which is greater than diffraction limit of the laser beam. *AS* pg. 18, lines 8-23; Figs. 8 and 9. The array of sub-beams is a sub-pattern of a reduced-size pattern formed on the work piece. *AS* pg. 14, line 13, through pg. 15, line 4; Fig. 6. A demagnifier is disposed in the optical path to form the reduced-size pattern of the array of sub-beams on the work piece. *AS* pg. 12, lines 1-5; Fig. 1. A translation stage is used to move the array of sub-beams in a direction perpendicular to the optical path, thus forming the array of holes of the second pitch size (i.e. the reduced-size pattern) on the work piece, when the laser beam is generated. *AS* pg. 10, lines 20-27, pg. 14, line 13, through pg. 15, line 4, and pg. 19, lines 15-26; Figs. 1 and 6. The second pitch size is approximately equal to the Rayleigh distance of $0.61*\lambda/N.A.$, where N.A. is a numerical aperture of a lens in the optical path. *AS* pg. 13, line 11, through pg. 14, line 12; Figs. 4 and 5.

Claim 26

Independent claim 26 broadly recites a method of drilling holes in a work piece. *AS* pg. 5, lines 12-28; Fig. 10. A laser beam that has been directed along an optical path is received. *AS* pg. 19, line 27, through pg. 20, line 2; Fig. 10. The laser beam is directed through a DOE that is disposed in the optical path, to form an array of angled sub-beams that have an angled beam pattern. *AS* pg. 18, lines 17-23; Figs. 9 and 10. The angled beam pattern is passed through a telecentric f-θ lens to form an array of sub-beams with a parallel pattern that has a first pitch size. *AS* pg. 18, lines 17-23; Figs. 9 and 10. The array of sub-beams is demagnified to form a reduced-size pattern of a second pitch size on the work piece. *AS* pg. 20, lines 3-13; Fig. 10. The array of sub-beams is translated in a direction perpendicular to their optical path such that, after translating the array of sub-beams, the reduced-size pattern of the second pitch size is formed on the work piece. *AS* pg. 20, lines 3-13; Fig. 10.

Claim 32

Independent claim 32 broadly recites a method of drilling holes in a work piece. *AS* pg. 5, lines 12-23; Fig. 10. A laser beam that has been directed along an optical path is received. *AS* pg. 19, line 27, through pg. 20, line 2; Fig. 10. The laser beam is directed through a beam former that is disposed in the optical path, to form an array of sub-beams with a parallel pattern that has a first pitch size and a density of 1/N times the image density of a reduced-size pattern to be formed on the work piece times a demagnification factor, where N is a positive integer. *AS* pg. 14, line 13, through pg. 15, line 4, and pg. 29, line 27, through pg. 20, line 2; Figs. 6 and 10. The array of sub-beams is demagnified to form the reduced-size pattern of a second pitch size on the work piece. *AS* pg. 20, lines 3-13; Fig. 10. The array of sub-beams is translated in a direction perpendicular to their optical path such that, after translating the array of sub-beams N-times, the reduced-size pattern of the second pitch size is formed on the work piece. *AS* pg. 14, line 13, through pg. 15, line 4, and pg. 20, lines 3-13; Figs. 6 and 10.

VI. <u>GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL</u>

Claims 1, 5, 7-14, 17-20, 22, 23, 25-29, and 32-34 stand rejected under 35 U.S.C. § 103(a) as unpatentable over U.S. Patent No. 6,433,303 to Liu et al. (Liu I) in view of U.S. Patent No. 6,433,305 to Liu et al. (Liu II) and U.S. Patent No. 5,296,673 to Smith (Smith). Claims 6 and 16 stand rejected under 35 U.S.C. § 103(a) as unpatentable over Liu I in view of Liu II and Smith and further in view of U.S. Patent No. 5,973,290 to Noddin (Noddin).

VII. ARGUMENT

A. ARGUMENT SUMMARY

1. APPELLANT'S INVENTION AS RECITED IN CLAIMS 1, 5, 7-14, 17-20, 22, 23, 25-29, and 32-34 IS PATENTABLE OVER THE DISCLOSURE OF LIU I IN VIEW OF THE DISCLOSURES OF LIU II AND SMITH BECAUSE LIU I, LIU II, AND SMITH DO NOT DISCLOSE, SINGLY OR IN COMBINATION, A MEANS FOR TRANSLATING AN ARRAY OF SUB-BEAMS IN A DIRECTION PERPENDICULAR TO THE OPTICAL PATH.

The issue on appeal with respect to this rejection of claims 1, 5, 7-14, 17-20, 22, 23, 25-29, and 32-34 is whether the disclosures of Liu I, Liu II, and Smith, singly or in combination, create a *prima facie* case of obviousness.

Appellant argues that the disclosures of Liu I, Liu II, and Smith, singly or in combination fail to teach or suggest every limitation of Appellant's independent claims 1, 5, 8, 11, 17, 20, 23, 26, and 32. Claim 1 includes a limitation that recites:

> ...<u>a translation stage coupled to the image interpolating mask</u> for moving the image interpolating mask and the array of sub-beams in a perpendicular direction to the optical path such that the array of sub-beams is moved in a sequence to form the reduced-size pattern on the work piece,... (Emphasis added.)

Independent apparatus claims 5, 8, 11, 17, 20, and 23 include a similar feature:

> ...a translation stage configured to move the array of sub-beams in a perpendicular direction to the optical path,...

as do independent method claims 26 and 32:

> ...translating the array of sub-beams N times in the perpendicular direction to the optical path;...

In the first non-final Office Action, originally filed claims 1, 2, 4, 7, 9-12, 14, 16, 18-20, 23, 26-30, 33, and 34 were rejected as unpatentable over Liu I in view of Liu II and Smith; however, the Examiner stated, on page 5 of the Office Action, that claims 3, 5, 8, 15, 17, 21, 22, 24, 25, 31, and 32 included patentable subject matter, but were been objected to as being dependent on a rejected claim. This statement was made without any specific discussion of the patentable subject matter.

Thus, Appellant did not argue that the previously quoted limitation of claim 1 distinguished over the cited references in response to the first, non-final Office Action. Instead Appellant amended independent claim 1 to include all of the features of dependent claims 2 and 3; independent claim 11 to include all of the features of dependent claim 15; independent claim 20 to include all of the features of dependent claim 21; independent claim 23 to include all of the features of dependent claim 24; and independent claim 26 to include all of the features of dependent claims 30 and 31. Appellant also amended claims 5, 8, 17, and 32 to be written in independent form and canceled claims 2-4, 15, 21, 24, 30, and 31.

Following this response, Appellant received a Final Office Action rejecting all of the same claims (including those that had been canceled) with an identical set of remarks. Although Appellant's previous response was listed on page 1 of this Office Action, the Examiner again stated that claims 3, 5, 8, 15, 17, 21, 22, 24, 25, 31, and 32 (including the now canceled claims 3, 15, 21, 24, and 31) included patentable subject matter, but were been objected to as being dependent on a rejected claim. No Response to Arguments was provided. The only change from the first Office Action was a new rejection of claim 11 as lacking enablement. After discussing this Final Office Action with the

Examiner and their supervisor, Appellant was forced to resubmit their previous response to avoid paying extension fees.

The Examiner reopened prosecution and issued a new non-final Office Action, rejecting claims 1, 5, 7-14, 17-20, 22, 23, 25-29, and 32-34 as unpatentable over Liu I in view of Liu II and Smith and maintaining the rejecting claim 11 as lacking enablement. The prior art rejections in this third Office Action included identical remarks to those in the first Office Action and did not address the inclusion of limitations from claims originally deemed to include patentable subject matter. Again, no Response to Arguments was provided.

In response to this Office Action, Appellant filed a response amending the specification to reorganize a couple paragraphs and clarify to support of claim 11 therein and amending claim 5, 11, and 32 to correct a minor clerical error. Because the Examiner had not provided specifics regarding the limitation deemed to include patentable subject matter in the first two Office Actions, Appellants chose to argue that no *prima facie* case of obviousness had been established based on the failure of Liu I, Liu II, and Smith, singly or in combination, to teach or suggest every limitation of Appellant's independent claims 1, 5, 8, 11, 17, 20, 23, 26, and 32, specifically, as quoted above, the use of a translation means to move the array of sub-beams in a direction perpendicular to the optical path in the claimed invention.

The subsequent Final Office Action included the identical prior art rejection and a brief Response to Arguments. In this Response to Arguments, the Examiner states that Appellant arguments are not persuasive, because Appellants have argued against the references individually. Appellants agree that it is not possible to show nonobviousness by arguing against references individually; however, Appellants argument is that no *prima*

facie case of obviousness exists because there is no teaching or suggestion of a claimed limitation in the cited prior taken singly <u>or in combination</u>.

The Examiner also states that "...the mask and the target may be adjusted with each other, that is, there is movement of the mask." This appears to be a characterization of Smith. Appellants agree that Smith discloses moving a mask <u>along the optical axis</u> ("...mask 4 can be moved along the optical axis by means not shown... ...to provide a method of altering the image size and thus the spacing of the apertures." Col. 4, lines 60-64.); however, the Examiner does not point to any teaching or suggestion of the use of a translation means to move the array of sub-beams <u>in a direction perpendicular to the optical path</u> in any of the prior art references.

2. APPELLANT'S INVENTION AS RECITED IN CLAIMS 6 AND 16 IS PATENTABLE OVER THE DISCLOSURE OF LIU I IN VIEW OF THE DISCLOSURES OF LIU II AND SMITH AND FURTHER IN VIEW OF NODDIN BECAUSE LIU I, LIU II, SMITH, AND NODDIN DO NOT DISCLOSE, SINGLY OR IN COMBINATION, A MEANS FOR TRANSLATING AN ARRAY OF SUB-BEAMS IN A DIRECTION PERPENDICULAR TO THE OPTICAL PATH.

The issue on appeal with respect to this rejection of claims 6 and 16 is whether the disclosures of Liu I, Liu II, Smith, and Noddin, singly or in combination, create a *prima facie* case of obviousness.

Claim 6 depends from independent claim 1 and claim 16 depends from independent claim 11. Thus, the combination of Liu I, Liu II, and Smith have at least the same deficiencies with regard to claims 6 and 16 as described above with regard to claims 1 and 11. Appellants argue that Noddin cannot overcome these deficiencies.

As argued above, no *prima facie* case of obviousness for claim 1 on the basis of Liu I, Liu II, and Smith exists because there is no teaching or suggestion in these references, singly or in combination, of the use of a translation means to move the array of sub-beams <u>in a direction perpendicular to the optical path</u>.

Noddin uses a single beam spot to form vias in a work piece. Therefore, Noddin cannot teach or suggest the use of a means for translating an array of sub-beams in a direction perpendicular to the optical path.

B. ISSUE

Claims 1, 5, 7-14, 17-20, 22, 23, 25-29, and 32-34 stand rejected under 35 U.S.C. § 103(a) as unpatentable over Liu I in view of Liu II and Smith. Claims 6 and 16 stand rejected under 35 U.S.C. § 103(a) as unpatentable over Liu I in view of Liu II and Smith and further in view of Noddin. These are the only rejections; there are no other rejections and no other applied references. The issue on appeal is whether Appellant's claimed invention is patentable over Liu I in view of Liu II and Smith and further in view of Noddin.

C. LEGAL STANDARD

> A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made. 35 U.S.C. § 103(a) (2007)

Section 103 requires that a claim be unobvious. That is, if the differences between the claim and the prior art are such that the subject matter of the claim as a whole would have been obvious at the time the invention was made to a person having ordinary skill in

the art, the claim is invalid. The test for obviousness is set forth in *Graham v. John Deere Co.*, 383 U.S. 1, (1966). The test requires determining the scope and content of the prior art, ascertaining the differences between the prior art and the claims at issue, and determining the level of ordinary skill in the pertinent art. Against this background, the obviousness or non-obviousness of the claimed subject matter is determined. *Graham v. John Deere Co.*, 383 U.S. 1, 17-18 (1966). Objective evidence (the fourth factual predicate referred to above) "may often establish that an invention appearing to have been obvious in light of the prior art is not." *Minnesota Mining & Mfg. Co. v. Johnson & Johnson Orthopaedics, Inc.*, 24 U.S.P.Q.2d 1321 (Fed. Cir. 1992).

Types of "objective evidence" considered with respect to the question of obviousness include: (1) the commercial success if it is due to the merits of the invention (but a "nexus" is required); (2) teaching away by prior art from claimed invention; (3) unexpected results; (4) copying of claimed invention by infringer; (5) long-felt need; (6) failure of others in the art; (7) uniqueness of claimed invention causing industry to embrace it, e.g., tributes to the patented invention by those in the industry; (8) passage of time from crucial prior art reference to claimed invention conceived; (9) license agreements with others in the industry (nexus between product licensed and claims required); and (10) skepticism of experts. The Federal Circuit has made clear that objective evidence, when present, must be considered in assessing nonobviousness. *Panduit Corp. v. Dennison Mfg. Co.*, 810 F.2d 1561, 1569, 1 USPQ2d 1593 (Fed. Cir. 1987).

To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the

reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art and not based on applicant's disclosure. *MPEP* §706.02(j), *citing In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991).

Appellant challenges the Office Action's rejections based on Liu I, Liu II, Smith, and Noddin because, singly or in combination, Liu I, Liu II, Smith, and Noddin fail to teach or suggest all the claim limitations of the pending claims. That is, each of Appellant's pending claims recites at least one feature that is not taught by Liu I, Liu II, Smith, or Noddin. Therefore, the Examiner has failed to present a *prima facie* case of obviousness and the Examiner's rejection of Appellant's pending claims under 35 U.S.C. §§ 103(a) are in error.

D. APPELLANT'S INVENTION AS RECITED IN CLAIMS 1, 5, 7-14, 17-20, 22, 23, 25-29, and 32-34 IS PATENTABLE OVER THE DISCLOSURE OF LIU I IN VIEW OF THE DISCLOSURES OF LIU II AND SMITH BECAUSE LIU I, LIU II, AND SMITH DO NOT DISCLOSE, SINGLY OR IN COMBINATION, A MEANS FOR TRANSLATING AN ARRAY OF SUB-BEAMS IN A DIRECTION PERPENDICULAR TO THE OPTICAL PATH.

It is settled law that Section 103 requires that a claim be unobvious. That is, if the differences between the claim and the prior art are such that the subject matter of the claim as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art, the claim is invalid. The test for obviousness is set forth in *Graham v. John Deere Co.*, 383 U.S. 1, (1966). However, the courts and the PTO have recognized that to establish a *prima facie* case of obviousness, three basic criteria must be

met. One of these criteria is that the prior art reference (or references when combined) must teach or suggest all the claim limitations. *MPEP* §706.02(j), *citing In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991).

The Examiner's rejection of independent of Appellant's independent claims 1, 5, 8, 11, 17, 20, 23, 26, and 32 on the basis of the disclosure of Liu I in view of the disclosures of Liu II and Smith fails to provide a *prima facie* case for obviousness. The Appellant's claim 1 includes a limitation that recites:

> ...<u>a translation stage coupled to the image interpolating mask</u> for moving the image interpolating mask and the array of sub-beams in a perpendicular direction to the optical path such that the array of sub-beams is moved in a sequence to form the reduced-size pattern on the work piece,... (Emphasis added.)

Independent apparatus claims 5, 8, 11, 17, 20, and 23 include a similar feature:

> ...a translation stage configured to move the array of sub-beams in a perpendicular direction to the optical path,...

as do independent method claims 26 and 32:

> ...translating the array of sub-beams N times in the perpendicular direction to the optical path;...

Thus, Applicant's invention, as recited in claims 1, 5, 7-14, 17-20, 22, 23, 25-29, and 32-34, use a translation means to move an array of sub-beams <u>in a perpendicular direction to the optical path</u>.

Because Liu II does not disclose or suggest the use of a mask, DOE, or array of sub-beams, Liu II cannot disclose a means for translating an array of sub-beams in a direction perpendicular to the optical path.

Liu I discloses using a mask or a DOE to form an array of sub-beams; however, Liu I does not disclose or suggest translating the array of sub-beams. Therefore, Liu I does

not disclose a means for translating an array of sub-beams in a direction perpendicular to the optical path.

Smith discloses using a mask to form an array of sub-beams. Smith also does that "...mask 4 can be moved along the optical axis by means not shown... ...to provide a method of altering the image size and thus the spacing of the apertures." Col. 4, lines 60-64. Smith does not, however, disclose or suggest translating the image formed by the mask in a direction perpendicular to the optical path.

Thus, Liu I, Liu II, and Smith, singly or in combination, do not teach or suggest the use of a means for translating an array of sub-beams in a direction perpendicular to the optical path as recited in the claimed invention. Every claimed limitation must be taught or suggested in the prior art to create a *prima facie* case of obviousness. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991). Therefore, the rejection of claims 1, 5, 7-14, 17-20, 22, 23, 25-29, and 32-34 as unpatentable over Liu I in view of Liu II and Smith is improper.

E. APPELLANT'S INVENTION AS RECITED IN CLAIMS 6 AND 16 IS PATENTABLE OVER THE DISCLOSURE OF LIU I IN VIEW OF THE DISCLOSURES OF LIU II AND SMITH AND FURTHER IN VIEW OF NODDIN BECAUSE LIU I, LIU II, SMITH, AND NODDIN DO NOT DISCLOSE, SINGLY OR IN COMBINATION, A MEANS FOR TRANSLATING AN ARRAY OF SUB-BEAMS IN A DIRECTION PERPENDICULAR TO THE OPTICAL PATH.

Claim 6 depends from independent claim 1 and claim 16 depends from independent claim 11. Thus, the combination of Liu I, Liu II, and Smith have at least the same deficiencies with regard to claims 6 and 16 as described above with regard to claims 1 and

11. Appellants argue that Noddin cannot overcome these deficiencies.

The Examiner's rejection of independent of Appellant's independent claims 1 and 11 on the basis of the disclosure of Liu I in view of the disclosures of Liu II and Smith and further in view of Noddin fails to provide a *prima facie* case for obviousness. The Appellant's claim 1 includes a limitation that recites:

> ...a translation stage coupled to the image interpolating mask for moving the image interpolating mask and the array of sub-beams in a perpendicular direction to the optical path such that the array of sub-beams is moved in a sequence to form the reduced-size pattern on the work piece,... (Emphasis added.)

Independent claim 11 includes a similar feature:

> ...a translation stage configured to move the array of sub-beams in a perpendicular direction to the optical path,...

Thus, Applicant's invention, as recited in claims 6 and 16, use a translation means to move an array of sub-beams in a perpendicular direction to the optical path.

As argued above, no *prima facie* case of obviousness for claim 1 on the basis of Liu I, Liu II, and Smith exists because there is no teaching or suggestion in these references, singly or in combination, of the use of a translation means to move the array of sub-beams in a direction perpendicular to the optical path.

Noddin uses a single beam spot to form vias in a work piece. Therefore, Noddin cannot teach or suggest the use of a means for translating an array of sub-beams in a direction perpendicular to the optical path.

Thus, Liu I, Liu II, Smith, and Noddin, singly or in combination, do not teach or suggest the use of a means for translating an array of sub-beams in a direction

perpendicular to the optical path as recited in the claimed invention. Every claimed limitation must be taught or suggested in the prior art to create a *prima facie* case of obviousness. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991). Therefore, the rejection of claims 6 and 16 as unpatentable over Liu I in view of Liu II and Smith and further in view of Noddin is improper.

F. CONCLUSION

Appellant has advanced reasons demonstrating that the disclosures of Liu I, Liu, Smith, and Noddin are insufficient as a basis for a *prima facie* case of obviousness of the pending claims. Accordingly, Appellants respectfully request the Board's reversal of these rejections.

Respectfully submitted,

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VIII. CLAIMS APPENDIX

1. A laser micromachining system for drilling holes in a work piece comprising:

a laser beam generator for directing a laser beam having a wavelength λ, along an optical path,

an image interpolating mask having an array of apertures, disposed in the optical path, for receiving the laser beam and forming a corresponding array of sub-beams of a first pitch size, the array of sub-beams being a sub-pattern of a reduced-size pattern formed on the work piece,

a demagnifier, disposed in the optical path, for forming the reduced-size pattern of the array of sub-beams on the work piece, the reduced-size pattern having a second pitch size, and

a translation stage coupled to the image interpolating mask for moving the image interpolating mask and the array of sub-beams in a perpendicular direction to the optical path such that the array of sub-beams is moved in a sequence to form the reduced-size pattern on the work piece,

wherein the second pitch size is less than λ and the first pitch size is greater than λ, and

when the laser beam is generated and the translation stage moves the array of sub-beams, the image interpolating mask is effective in forming an array of holes having the second pitch size.

5. A laser micromachining system for drilling holes in a work piece comprising:

a laser beam generator for directing a laser beam having a wavelength λ, along an optical path,

an image interpolating mask having an array of apertures, disposed in the optical path, for receiving the laser beam and forming a corresponding array of sub-beams of a first pitch size,

a translation stage configured to move the array of sub-beams in a perpendicular direction to the optical path, and

a demagnifier, disposed in the optical path, for forming the reduced-size pattern of the array of sub-beams on the work piece, the reduced-size pattern having a second pitch size,

wherein the second pitch size is less than λ and the first pitch size is greater than λ,

the array of apertures of the image interpolating mask has an aperture density of 1/N times an image density of the reduced-size pattern on the work piece times a demagnification factor of the demagnifier, N being a positive integer,

when the laser beam is generated and the translation stage moves the array of sub-beams, the image interpolating mask is effective in forming an array of holes having the second pitch size, and

the array of sub-beams is configured to translate N-times in the perpendicular direction to the optical path by the translation stage to form the array of holes of the second pitch size.

6. The laser micromachining system of claim 1 wherein

the laser beam generator includes a pulsed laser providing a pulsed-on period of less than 200 femtoseconds, and

a harmonic generating crystal, coupled to the pulsed laser, for providing a harmonic frequency of the pulsed laser to produce the laser beam having the wavelength of λ.

7. The laser micromachining system of claim 1 wherein

the demagnifier includes a first lens having a first focal length and a microscope objective having a second focal length, and

a demagnification factor resulting from the first focal length divided by the second focal length.

8. A laser micromachining system for drilling holes in a work piece comprising:

a laser beam generator for directing a laser beam having a wavelength λ, along an optical path,

an image interpolating mask having an array of apertures, disposed in the optical path, for receiving the laser beam and forming a corresponding array of sub-beams of a first pitch size, each of the sub-beams including a Gaussian intensity distribution,

a translation stage configured to move the array of sub-beams in a perpendicular direction to the optical path, and

a demagnifier, disposed in the optical path, for forming the reduced-size pattern of the array of sub-beams on the work piece, the reduced-size pattern having a second pitch size,

wherein the second pitch size is less than λ and the first pitch size is greater than λ,

a hole of the array of holes has a diameter of approximately less than or equal to the full width at half maximum (FWHM) of the Gaussian intensity distribution, and

when the laser beam is generated and the translation stage moves the array of sub-beams, the image interpolating mask is effective in forming an array of holes having the second pitch size.

9. The laser micromachining system of claim 1 wherein

a scanning mirror is provided in the optical path behind the laser beam generator for uniformly distributing the laser beam onto the image interpolating mask.

10. The laser micromachining system of claim 1 wherein

the second pitch size is less than a diffraction limit of the laser beam, and

the first pitch size is greater than the diffraction limit of the laser beam multiplied by a demagnification factor of the demagnifier.

11. A laser micromachining system for drilling holes in a work piece comprising:

a laser beam generator for directing a laser beam along an optical path, the laser beam having a wavelength of λ,

a diffraction optical element (DOE) and a telecentric f-θ lens disposed in the optical path for receiving the laser beam and forming an array of sub-beams, the array of sub-beams having a first pitch size,

a translation stage configured to move the array of sub-beams in a perpendicular direction to the optical path, and

a demagnifier for forming a reduced-size pattern of the sub-beams onto the work piece, the reduced-size pattern having a second pitch size,

wherein the second pitch size is less than λ and the first pitch size is greater than λ,

the array of sub-beams has a density of 1/N times an image density of the reduced-size pattern on the work piece times a demagnification factor of the demagnifier, N being a positive integer,

when the laser beam is generated and the translation stage moves the array of sub-beams, the DOE and the telecentric f-θ lens are effective in forming an array of holes having the second pitch size, and

the array of sub-beams is configured to translate N-times in a perpendicular direction to the optical path by the translation stage to form the array of holes of the second pitch size.

12. The laser micromachining system of claim 11 wherein

the array of sub-beams formed by the DOE and the telecentric f-θ lens are a sub-pattern of the reduced-size pattern formed on the work piece, and

the translation stage is configured to move the array of sub-beams in a sequence to form the reduced-size pattern on the work piece.

13. The laser micromachining system of claim 12 wherein

the translation stage is coupled to the telecentric f-θ lens for moving the telecentric f-θ lens and the array of sub-beams.

14. The laser micromachining system of claim 12 wherein

the translation stage is coupled to a work piece holder holding the work piece for moving the work piece with respect to the array of sub-beams.

16. The laser micromachining system of claim 11 wherein

the laser beam generator includes a pulsed laser providing a pulsed-on period of less than 200 femtoseconds, and

a harmonic generating crystal, coupled to the pulsed laser, for providing a harmonic frequency of the pulsed laser to produce the laser beam having the wavelength of λ.

17. A laser micromachining system for drilling holes in a work piece comprising:

a laser beam generator for directing a laser beam along an optical path, the laser beam having a wavelength of λ,

a diffraction optical element (DOE) and a telecentric f-θ lens disposed in the optical path for receiving the laser beam and forming an array of sub-beams, the array of sub-beams having a first pitch size, each of the sub-beams including a Gaussian intensity distribution,

a translation stage configured to move the array of sub-beams in a perpendicular direction to the optical path, and

a demagnifier for forming a reduced-size pattern of the sub-beams onto the work piece, the reduced-size pattern having a second pitch size,

wherein the second pitch size is less than λ and the first pitch size is greater than λ,

a hole of the array of holes has a diameter of approximately less than or equal to the full width at half maximum (FWHM) of the Gaussian intensity distribution, and

when the laser beam is generated and the translation stage moves the array of sub-beams, the DOE and the telecentric f-θ lens are effective in forming an array of holes having the second pitch size.

18. The laser micromachining system of claim 11 wherein

a scanning mirror is provided in the optical path behind the laser beam generator for uniformly distributing the laser beam onto the DOE.

19. The laser micromachining system of claim 11 wherein

the second pitch size is less than a diffraction limit of the laser beam, and

the first pitch size is greater than the diffraction limit of the laser beam multiplied by a demagnification factor of the demagnifier.

20. A laser micromachining system for drilling holes in a work piece comprising:

a laser beam generator for directing a laser beam having a wavelength λ, along an optical path,

an image interpolating mask having an array of apertures, disposed in the optical path, for receiving the laser beam and forming a corresponding array of sub-beams of a first pitch size,

a translation stage configured to move the array of sub-beams in a perpendicular direction to the optical path, and

a demagnifier, disposed in the optical path, for forming a reduced-size pattern of the array of sub-beams on the work piece, the reduced-size pattern having a second pitch size,

wherein the second pitch size is approximately equal to a Rayleigh distance of $0.61*\lambda/N.A.$, where N.A. is a numerical aperture of a lens in the optical path,

the first pitch size is greater than the diffraction limit of the laser beam, and

when the laser beam is generated and the translation stage moves the array of sub-beams, the image interpolating mask is effective in forming an array of holes having the second pitch size.

22. The laser micromachining system of claim 20 wherein

the second pitch size is approximately equal to 1.5* Rayleigh distance.

23. A laser micromachining system for drilling holes in a work piece comprising:

a laser beam generator for directing a laser beam along an optical path, the laser beam having a wavelength of λ,

a diffraction optical element (DOE) and a telecentric f-θ lens disposed in the optical path for receiving the laser beam and forming an array of sub-beams, the array of sub-beams having a first pitch size,

a translation stage configured to move the array of sub-beams in a perpendicular direction to the optical path, and

a demagnifier for forming a reduced-size pattern of the sub-beams onto the work piece, the reduced-size pattern having a second pitch size,

wherein the second pitch size is approximately equal to a Rayleigh distance of $0.61*\lambda/N.A.$, where N.A. is a numerical aperture of a lens in the optical path,

the first pitch size is greater than the diffraction limit of the laser beam, and

when the laser beam is generated and the translation stage moves the array of sub-beams, the DOE and the telecentric f-θ lens are effective in forming an array of holes having the second pitch size.

25. The laser micromachining system of claim 23 wherein

the second pitch size is approximately equal to 1.5* Rayleigh distance.

26. A method of drilling holes in a work piece comprising the steps of:

(a) receiving a laser beam directed along an optical path;

(b) directing the laser beam through a DOE, disposed in the optical path, to form an array of angled sub-beams having an angled beam pattern;

(c) passing the angled beam pattern through a telecentric f-θ lens to form an array of sub-beams in a parallel pattern of a first pitch size;

(d) demagnifying the array of sub-beams to form a reduced-size pattern of a second pitch size on the work piece;

(e) translating the array of sub-beams in a perpendicular direction to the optical path; and

(f) after translating the array of sub-beams in the perpendicular direction to the optical path, forming the reduced-size pattern of the second pitch size on the work piece.

27. The method of claim 26 wherein

step (a) includes receiving the laser beam having a wavelength of λ;

step (c) includes forming the array of sub-beams with a pitch size greater than the wavelength of λ; and

step (f) includes forming the reduced-size pattern on the work piece with a pitch size smaller than the wavelength of λ.

28. The method of claim 26 wherein the first pitch size is larger than the second pitch size by a factor of P times a demagnification factor provided by the demagnifying step, P being a positive integer; and

step (e) includes translating the array of sub-beams in the perpendicular direction P times; and

step (f) includes after translating the array of sub-beams P times, forming the reduced-size pattern of the second pitch size on the work piece.

29. The method of claim 32 wherein

step (b) includes directing the laser beam through an image interpolating mask having an array of apertures, and

forming the array of sub-beams after passing the laser beam through the array of apertures.

32. A method of drilling holes in a work piece comprising the steps of:

(a) receiving a laser beam directed along an optical path;

(b) directing the laser beam through a beam former, disposed in the optical path, to form an array of sub-beams of a first pitch size, the array of sub-beams having a density of 1/N times an image density of a reduced-size pattern to be formed on the work piece times a demagnification factor, N being a positive integer;

(c) demagnifying the array of sub-beams by the demagnification factor to form the reduced-size pattern of a second pitch size on the work piece;

(d) translating the array of sub-beams N times in the perpendicular direction to the optical path; and

(e) after translating the array of sub-beams N times, forming the reduced-size pattern on the work piece.

33. The method of claim 32 wherein

step (d) includes coupling a translation stage to the beam former for translating the array of sub-beams in the perpendicular direction to the optical path.

34. The method of claim 26 wherein

step (e) includes coupling a translation stage to a work piece holder for translating the array of sub-beams in the perpendicular direction with respect to the optical path.

RELATED PROCEEDINGS APPENDIX

None

EVIDENCE APPENDIX

None